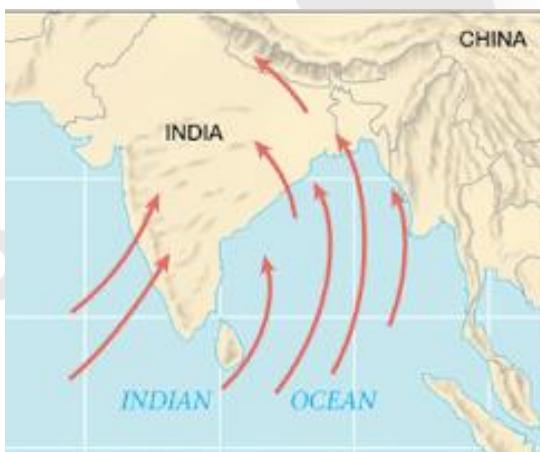
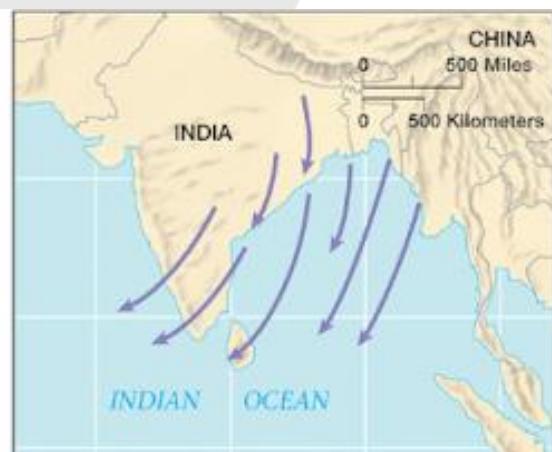


# Monsoon in India



Summer \_\_\_\_\_



Winter

- ✓ The term monsoon has been derived from the Arabic word mausin meaning 'season'.
- ✓ Monsoons are seasonal winds (Rhythmic wind movements)(Periodic Winds) which reverse their direction with the change of season.
- ✓ The monsoon is a double system of seasonal winds – They flow from sea to land during the summer and from land to sea during winter.
- ✓ India receives south-west monsoon winds in summer and north-east monsoon winds in winter.
- ✓ South-west monsoons are formed due to intense low pressure system formed over the Tibetan plateau.
- ✓ North-east monsoons are associated with high pressure cells over Tibetan and Siberian plateaus.
- ✓ South-west monsoons bring intense rainfall to most of the regions in India and north-east monsoons bring rainfall to mainly south-eastern coast of India (coast of Tamil Nadu.).
- ✓ Countries like India, Indonesia, Bangladesh, Myanmar etc. receive most of the annual rainfall during south-west monsoon season where as South East China, Japan etc., during north-east rainfall season.

## Classical Theory

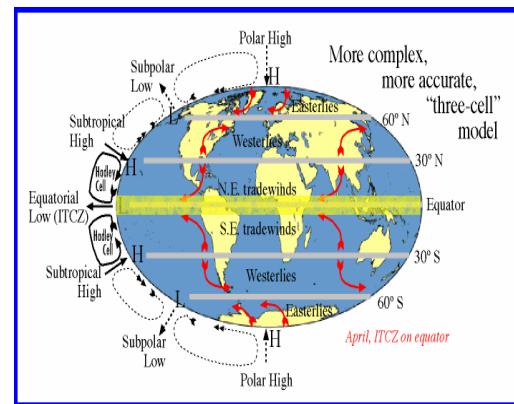
- ✓ Monsoons are mentioned in scriptures like the Rig Veda. But these scriptures didn't make any mention of the monsoon mechanism.
- ✓ The first scientific study of the monsoon winds was done by Arab traders.
- ✓ Arab traders used the sea route to carry out trade with India and monsoon patterns were of prime importance for them.
- ✓ In the tenth century, Al Masudi, an Arab explorer, gave an account of the reversal of ocean currents and the monsoon winds over the north Indian Ocean.
- ✓ In seventeenth century, **Sir Edmund Halley** explained the monsoon as resulting from thermal contrasts between continents and oceans due to their differential heating.

## Thermal Concept

- ✓ **Summer Monsoon**
- ✓ In summer the sun's apparent path is vertically over the Tropic of Cancer resulting in high temperature and low pressure in Central Asia.
- ✓ The pressure is sufficiently high over Arabian Sea and Bay of Bengal. Hence winds flow from Oceans flow towards landmass in summer.
- ✓ This air flow from sea to land bring heavy rainfall to the Indian subcontinent.
- ✓ **Winter Monsoon**
- ✓ In winter the sun's apparent path is vertically over the Tropic of Capricorn.
- ✓ The north western part of India grows colder than Arabian Sea and Bay of Bengal and the flow of the monsoon is reversed.
- ✓ The basic idea behind Classical theory is similar to land and sea breeze formation except that in the case of monsoons the day and night are replaced by summer and winter.

# Indian Monsoons – Role of ITCZ [Inter-Tropical Convergence Zone]

- The southeast trade winds in the southern hemisphere and the northeast trade winds in the northern hemisphere meet each other near the equator.
- The meeting place of these winds is known as the Inter-Tropical Convergence Zone (ITCZ).



- This is the region of ascending air, maximum clouds and heavy rainfall.
- The location of ITCZ shifts north and south of equator with the change of season.
- In the summer season, the sun shines vertically over the Tropic of Cancer and the ITCZ shifts northwards.
- The southeast trade winds of the southern hemisphere cross the equator and start blowing in southwest to northeast direction under the influence of Coriolis force.
- These displaced trade winds are called south-west monsoons when they blow over the Indian sub-continent.
- The front where the south-west monsoons meet the north-east trade winds is known as the Monsoon Front (ITCZ). Rainfall occurs along this front.

- In the month of July the ITCZ shifts to 20°- 25° N latitude and is located in the Indo-Gangetic Plain and the south-west monsoons blow from the Arabian Sea and the Bay of Bengal. The ITCZ in this position is often called the Monsoon Trough [maximum rainfall].
- The seasonal shift of the ITCZ has given the concept of Northern Inter-Tropical Convergence Zone (NITCZ) in summer (July – rainy season) and Southern Inter-Tropical Convergence Zone (SITCZ) in winter (Jan – dry season).
- NITCZ is the zone of clouds and heavy rainfall that effect India.

## Role of the Himalayas and Tibetan Plateau

- In the 1970s, it was found that the Tibet plateau plays a crucial role in initiating the monsoon circulation. The plateau of Tibet extends over an area of about 4.5 million sq. km. The average height of these highlands is 4000 m. Due to its enormous height, it receives 2-3oC more insolation than the neighbouring areas. The heating of these areas leads to clockwise air circulation in the middle troposphere and two-wind streams originate from this area. One of these wind streams blows southward and develops into the tropical easterly jet stream (TEJ). The other stream blows in an opposite direction towards the North Pole and becomes the westerly jet stream over Central Asia.



Tibet anti-cyclone and Easterly Jet stream

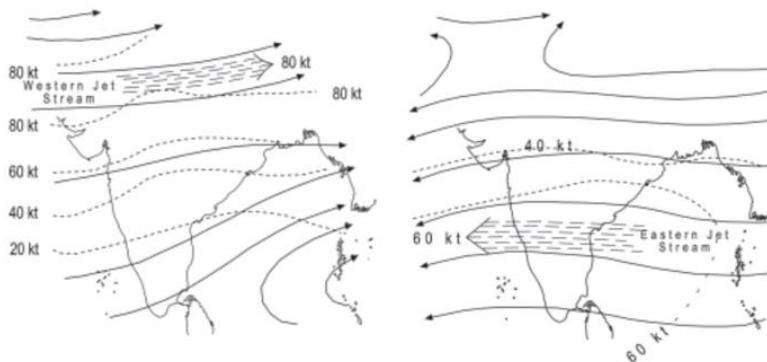
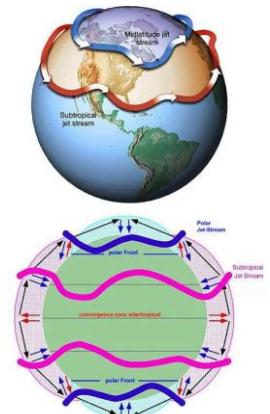
- Northward movement of the sun in summer
- Heating of Tibetan plt –LP
- Rising of the air
- Create TEJ above Tibet – move towards Mascarene High
- Strengthen Mascarene High pressure cell

## Role of Jet Stream

- The Jet Stream is a geostrophic wind blowing horizontally through the upper layers of the troposphere, generally from west to east, at an altitude of 20,000 - 50,000 feet.
- Jet Streams develop where air masses of differing temperatures meet. So, usually surface temperatures determine where the Jet Stream will form.
- Greater the difference in temperature, faster is the wind velocity inside the jet stream.
- Jet Streams extend from 20 degrees latitude to the poles in both hemispheres.

## Indian Monsoon Mechanism and the Role of Sub Tropical Jet Streams

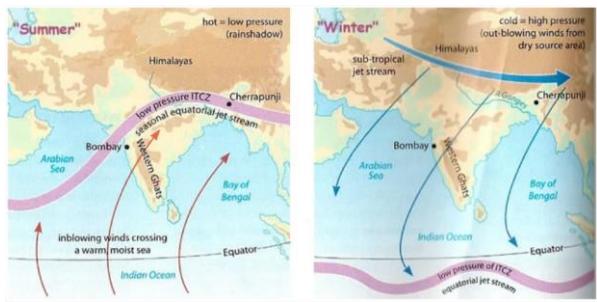
- The burst of monsoons depends upon the upper air circulation which is dominated by Sub Tropical Jet Streams (STJ).
- The south west monsoon coming in India is related to tropical easterly stream. It blows between 8 degree- 35 degree North latitudes.
- The north east monsoon (winter monsoon) is related to the subtropical westerly Jet Stream which blows between 20 degree and 35 degree latitudes in both hemispheres.



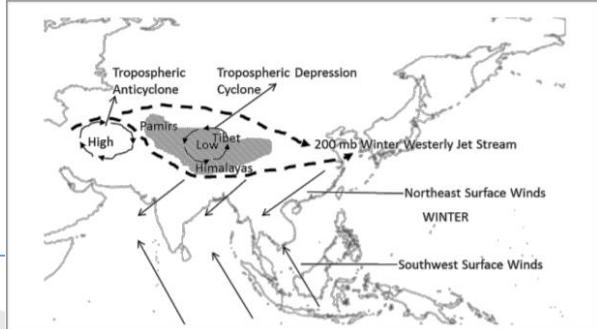
- Two prominent jet streams affect the monsoon winds, the sub-tropical westerly jet stream and equatorial easterly jet stream.
- Sub-tropical westerly jet stream: It dominates in winter time in upper troposphere circulation of the northern latitudes and can be located over Indian sub-continent at a height of about 12 km. Himalayan mountain system splits the jet stream into two parts. The jet stream south of Himalaya tends to descend over north- western part of India resulting in atmospheric stability.
- Equatorial easterly jet stream: This jet is a prominent feature of the upper air circulation during the Indian monsoon season appearing as a band of strong easterlies extending from south East Asia across the Indian Ocean and Africa to the Atlantic.

## 5 Key players in Monsoon:

- 1) Differential heating and cooling of land (LP) and Sea (HP) in summer.
- 2) Northward shifting of ITCZ in July over Ganga plains



- 3) The presence of High Pressure (HP) area over Madagascar (20°S of Indian Ocean). The intensity and position of this HP area affects Indian monsoon.
- 4) Tibetan plateau gets intensely heated



- 5) The presence of Tropical Easterly Jetstream over peninsula in summer. It is associated closely with the burst of Monsoon.
- Role of Tibetan Plateau: It is the highest & largest plateau of the world w avg height of 4000 m and is surrounded by even higher mountain ranges.
- In summer, Tibetan Plateau acts as a heat source. Air above it is heated & is warmer compared to the surrounding air of mountain ranges. Warm air rises above and creates HP belt in the upper air above Tibetan plateau. Air spreads from HP belt and sinks over Indian Ocean around 30°S and 70°E.
- This movement from Tibet to IO is known as Tropical Easterly Jet (TEJ). This jet drives monsoonal winds towards Indian subcontinent and intensifies SW monsoon.
- The area over IO where TEJ sinks is known as Mascarene High.
- It is a major reason why there are no cyclones over the Indian landmass. It is present in the Upper troposphere & prevents d vertical circulation of air which is a pre-condition for formation of cyclone.

## South-West Monsoon

Definition: It is the seasonal reversal in the wind direction. It is experienced in tropical areas (20°N to 20°S). In India, it is experienced in June, July, August and September.



- 1) Onset and Landward advance of Monsoon from Kerala:

Differential heating of land (LP) and sea (HP) in summer.

Northward shift of ITCZ.

Heating of Tibetan plateau and inducement of TEJ.

- 2) Rain bearing systems:

Monsoon rainfall enters in India in 2 branches, Arabian Sea branch of SW Monsoon brings rain to West coast and further interiors of Peninsula (It is related to offshore meteorological conditions along eastern coast of Africa) and BoB Bengal branch gives rainfall over Eastern, NE and NI. Tropical depressions originating in BoB cause rainfall in Northern plains.

**Arabian Sea Branch of SW Monsoon:** The total volume is 3 times more than BoB branch. It approaches Southwest coast of India by the 1st week of June. They further split into 3 branches:

### Western Ghats (WG):

The high WG leads the moist air to rise quite high. Heavy rain (200-250 cms) falls on the windward slopes of WG.

The leeward side receives only 60 cm rainfall & rain shadow areas receive much less.

The winds progressively deposit less rainfall from West to East Ex. Mumbai-200 cm & Chennai-40 cm and from S to N Ex. Thiruvan-puram-325 cm, GA-300 cm & Mumbai-200 cm.

**North of Mumbai:** After crossing the Ghats the monsoon winds cross the plateau & reach MP, JH and OD giving rainfall. Part of this wind enters through Narmada valley & causes good rainfall in the Chota Nagpur plateau. Further North, a part of these winds passes over West and Southeast Rajasthan without depositing much rainfall and goes straight to the sub-Himalayan region giving rainfall to the foothills of the W Himalayas, eastern PN, HR and NE RJ where it meets the BoB branch.

**Saurashtra Peninsula and Kachch:** Aravallis runs almost parallel to the direction of this branch and do not form a barrier to intercept the winds, and hence do not receive much rainfall from this branch.

### • Bay of Bengal branch of SW Monsoon:

- These winds pass over Ganga and Brahmaputra delta strike against Shiwalik ranges, Himalayas, Chittagong and Assam hills, then rise and cause heavy rainfall in WB, SK, AR and southern slopes of Khasi-Jaintia hills. Mawsynram / Cherrapunji (1250 cm) receives the highest rainfall in the World.
- 1 branch of BoB branch is deflected in Western direction, blowing from SE, between Himalayas and Peninsula. The winds move up in the Indo gangetic plain parallel to Himalayas.
- The rainfall decreases up to Kashmir from Ganga plains (250 cm).

### Why Tamil Nadu dry during this season?

- TN coast is parallel to BoB branch of SW monsoon.
- It lies in the rain shadow region of Arabian Sea branch of SW Monsoon.



## Retreating Monsoon Season

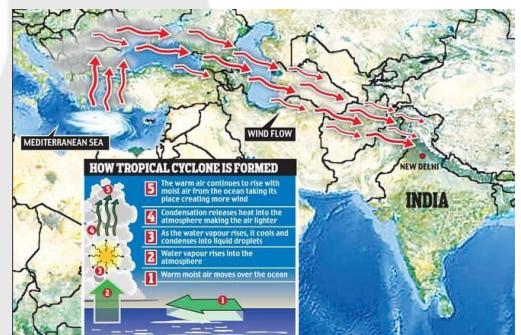
- The retreating southwest monsoon season is marked by clear skies and rise in temperature.
- The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the 'October heat'.
- In the second half of October, the mercury begins to fall rapidly, particularly in northern India.
- The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the雨iest months of the year.
- The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive.
- A bulk of the rainfall of the Coromandel Coast is derived from these depressions and cyclones.
- Unlike the rest of the country, which receives rain in the southwest monsoon season between June and September, the northeast monsoon is crucial for farming and water security in the south.

# Western Disturbance

- Origin and development of Western Disturbance:
- The origin of Western Disturbance is the Mediterranean sea.
- Evaporated moisture from the Mediterranean sea condenses and forms clouds in the atmosphere. Due to the presence of the Subtropical Westerly Jet stream over the upper atmosphere over the Mediterranean sea and comparatively low atmospheric pressure present in the Indian Subcontinents; it causes drift towards India Subcontinents. Himalayan acts as a barrier to this coming moisture cause the rainfall in the northwestern part of India.



- Impact of Western disturbances in India:
- Night temperature get increase before the western disturbance
- It causes rainfall in winter from December to March.
- Day temperature decreases.
- Cause moderate to heavy rainfall in the northwestern part of India specially Punjab, Haryana, northwestern UP, and the western Himalayas.
- Moderate rainfall helps Rabi crops
- Heavy rainfall causes flood and crop damage to plains areas.
- Heavy rainfall or snowfall cause landslide and Avalanche in Western Himalayan.



Parcham Classes

## MCQ

1. In which monsoon, the Sun shines vertically over the Tropic of Cancer resulting in high temperature and low pressure is still sufficiently high over Arabian Sea and Bay of Bengal?
  - A. Winter Monsoon
  - B. Summer Monsoon
  - C. Retreating Monsoon
  - D. All of the above
2. Which of the following statement is correct about the Inter-Tropical Convergence Zone (ITCZ)?
  - A. ITCZ shifts only between 50° to 75° of latitude north or south of the equator
  - B. It is a zone between the northern and southern hemisphere where winds blowing poleward from the mid latitudes and winds flowing from equator-ward the tropics meet.
  - C. It is also known as the Tropical Convergence Zone.
  - D. It is a zone of convergence where the trade winds meet.
3. Where are horse latitudes located?
  - A. 30 degrees north and south of the equator
  - B. 40 degrees north and south of the equator
  - C. 60 degrees north and south of the equator
  - D. 50 degrees north and south of the equator
4. Which part of India receives rainfall from both the South-West and North-West monsoons?
  - A. Tamilnadu
  - B. Odisha
  - C. Lakshadweep Islands
  - D. Andaman and Nicobar Islands
5. The Paddy fields of India are located in the areas of annual rainfall
  - A. 120cm
  - B. 140cm
  - C. 100cm
  - D. 80cm
6. Which region gets first monsoon in summer?
  - A. Himalayas
  - B. Western Ghats
  - C. Eastern Ghats
  - D. Gangetic Plain

7. The northeastern hills that block the South West Monsoon winds and cause heavy rains in Assam are

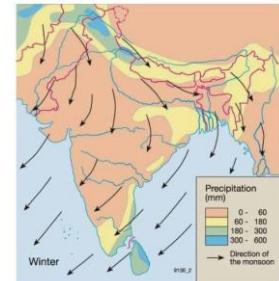
- A. Arakan Yoma and Pegu Yoma
- B. Garo Khasi and Jaintia hills
- C. Barail and Patkai hills
- D. Khasi and Pegu Yoma

8. The reason for Rajasthan being deficient in rainfall is \_\_\_\_\_

- A. The monsoon fail to reach this area
- B. It is too hot
- C. There is no water available and thus the winds remain dry
- D. The winds do not come across any barrier to cause necessary uplift to be cooled

9. The retreating monsoon withdraws itself from

- A. The west coast to the east coast
- B. North-East India to the west coast
- C. The north to the south
- D. North-West India to Bengal and then to Kerala



1. Ans:B

2. Ans:D

3. Ans:A

4. Ans:D

5. Ans:C

6. Ans:B

7. Ans:B

8. Ans:d

9. Ans:D